CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

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TECHNICAL CATEGORY E: NATURAL RESOURCES, MINING, INDUSTRY & ENERGY

Knight Piésold CONSULTING

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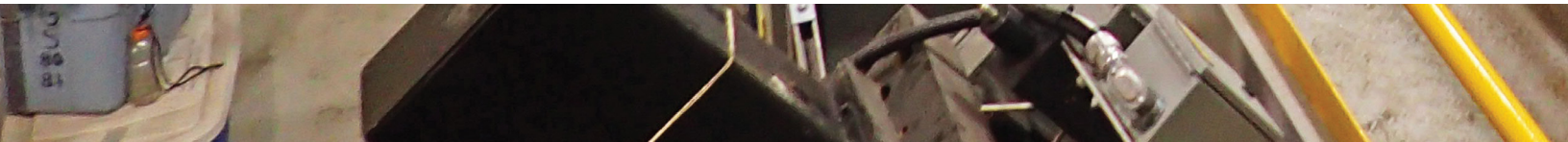

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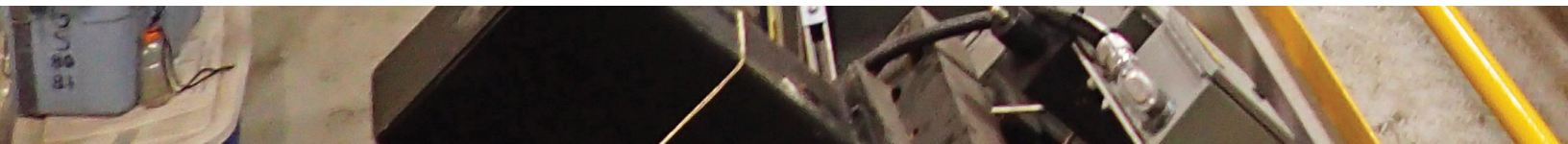
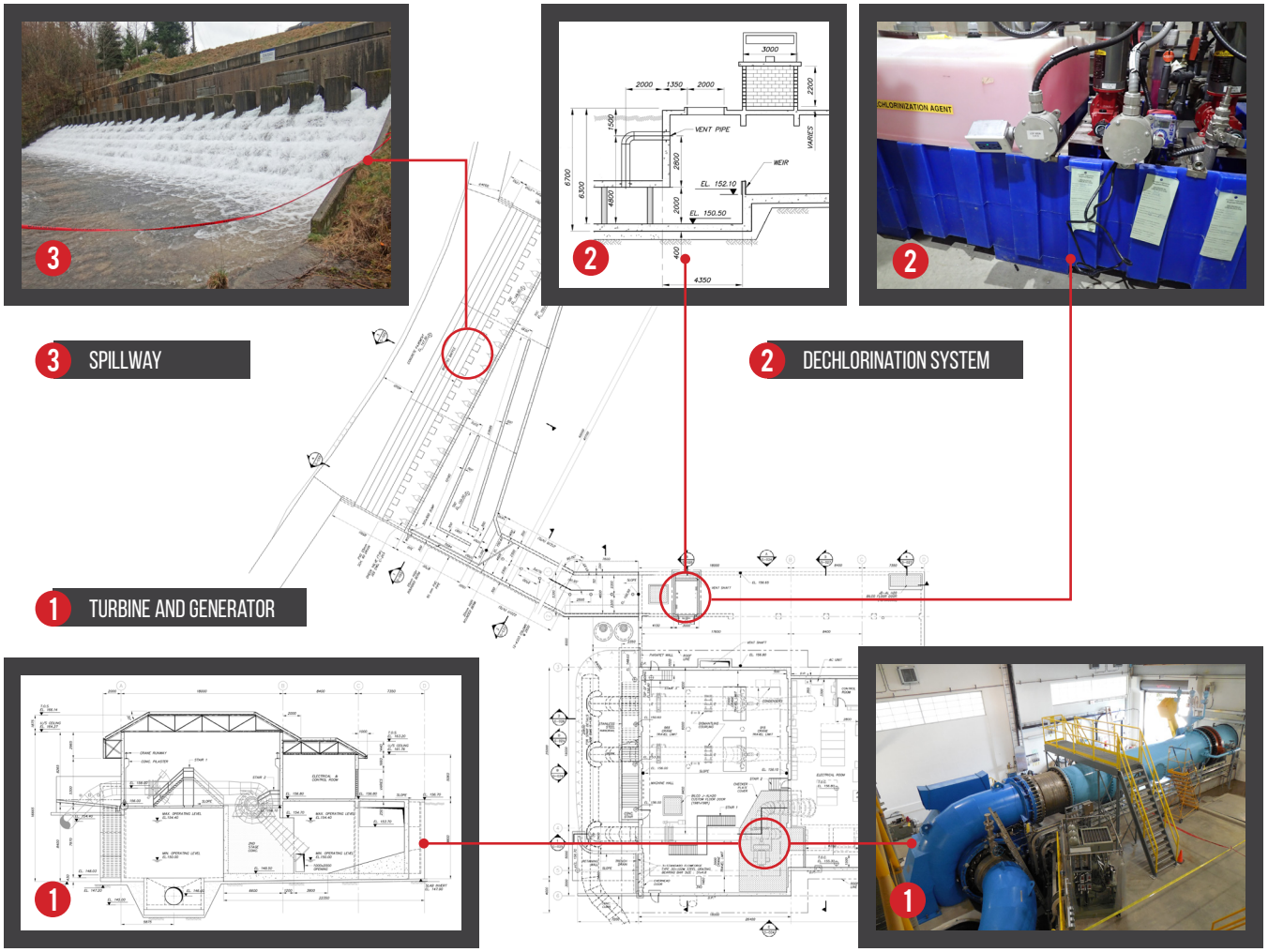


CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT SUMMARY

Knight Piésold designed and commissioned the Capilano Break Head Tank and Energy Recovery Facility to provide reliable water supply continuity and dissipate excess pressure in clean drinking water before it is delivered to residents and businesses in Greater Vancouver. The energy recovered is used to partially offset power consumption in Metro Vancouver's Capilano Pump Station. The facility includes one of the largest energy recovery turbines in a municipal treated potable water system in North America.



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CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

INNOVATION

The Capilano Break Head Tank and Energy Recovery Facility (BHT/ERF) is a vital link in the new Seymour-Capilano Water Filtration System that supplies treated potable water to the cities of Vancouver, North Vancouver, and Burnaby. It is located adjacent to the Capilano Reservoir and the Cleveland Dam, at the terminus of a 7-km-long, gravity-driven tunnel from the Seymour-Capilano Filtration Plant (SCFP). Excess pressure is created when treated potable water from the SCFP—located 30 m higher in elevation—passes through the tunnel for delivery to the Capilano distribution system.

Knight Piesold Ltd. (Knight Piésold) designed and commissioned the BHT/ERF to provide reliable water supply continuity and dissipate excess pressure in clean drinking water before it is delivered to consumers in the cities. Knight Piésold worked closely with the Owner Metro Vancouver to create innovative solutions not normally required in a typical hydroelectric or water supply facility in order to install and commission one of the largest energy recovery turbines in a municipal treated potable water system in North America.

ENERGY RECOVERY FACILITY

The BHT/ERF showing the energy recovery turbine and pressure reducing valves.

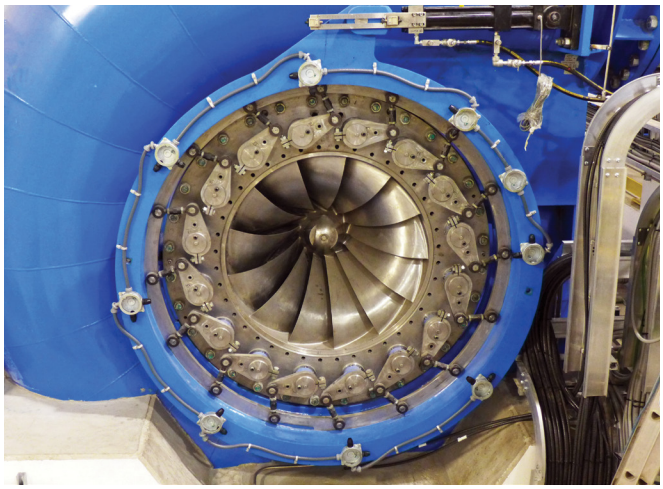
CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

The BHT/ERF can either dissipate excess gravity-fed water pressure through pressure reducing valves (PRVs) or convert the excess pressure and flow to electricity through a hydroelectric turbine to recover energy that otherwise would be lost. It is expected to generate power to reduce Metro Vancouver's total energy consumption by approximately 9,600 MWh/year.

Two multi-orifice sliding-disc-type PRVs provide reliable continuity of water supply. Each valve is capable of delivering the full 12.5 m^3/s design flow of the facility, and the control systems are fully redundant, so any single point failure will not jeopardize supply continuity. The turbine and PRVs discharge into a large underground concrete break head tank, connected to the city water mains, to maintain a constant water supply level in response to varying demands from consumers in the cities. The commissioned system has been shown to seamlessly maintain water supply under all anticipated failure modes.

Taking into account the sensitive aquatic habitat in the Capilano Reservoir, Knight Piésold developed and upgraded a dechlorination system that is able to cover a wide range of overflow conditions and to accurately deliver a metered dosage of calcium thiosulphate into the treated water. This neutralizes the residual chlorine in the water before it is discharged into the Capilano Reservoir through the emergency overflow channel in the event of a system failure, making it safe for aquatic species.



ENERGY RECOVERY TURBINE

The 4.5 m diameter Francis turbine.

PRESSURE REDUCING VALVE

One of the two 1.676 m diameter pressure reducing valves.

CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

The BHT/ERF includes the following key components:

Facility Design Flow	12.5 m^3/s	Transformer	2 MVA, 4.16 kV to 13.8 kV
Pressure Reducing Valves	2 x 1.676 m diameter sliding disc type (12.5 m^3/s each)	Energy Recovery Generator	Horizontal axis synchronous (1,687 kW)
Energy Recovery Turbine	Horizontal axis Francis (7.5 m^3/s)	Dechlorination System	Metered calcium thiosulphate dosing system

UNDERGROUND BREAK HEAD TANK

The turbine and PRVs discharge into an underground break head tank, which maintains a stable supply level for the Capilano distribution system.

ENERGY RECOVERY GENERATOR

The 1,687 kW horizontal axis generator.

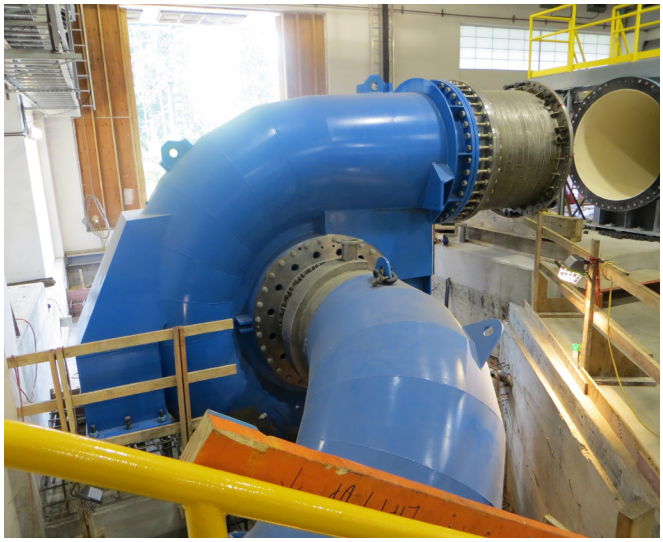
CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

COMPLEXITY

The installation and commissioning of the energy recovery turbine, which has a 1.676 m diameter inlet pipe and a 4.5 m diameter spiral case, had little precedent in North America due to its size and scale.

The difference in elevation causes the turbine to experience a variation of over 60% in pressure head that required automatic trip capabilities to be implemented into the control system, so that the turbine shuts down when the pressure head falls out of the allowable turbine range. The operating system permits operation of either the PRVs or the turbine alone, or both devices together, to meet varying demands from the cities under a level control scheme in the tank.



INSTALLATION

The installation of the turbine, which is larger than the bay door originally built in the facility, required a south wall temporary blockout wall to be constructed to allow for the component to be lifted into the facility and be placed in a large concrete block-out prepared in the initial tank construction.

COMMISSIONING

The commissioning involved discharging 9.5 m^3/s of dechlorinated water into the Capilano Reservoir.

CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

The design required modelling of tunnel and turbine surge characteristics to identify operating times that would not permit overpressures due to water hammer effects during turbine load rejections. The tank is provided with an underground overflow weir to prevent surcharging of the tank during a valve failure. The overflow weir is connected to the Capilano Reservoir through an underground channel and a large energy dissipating spillway. The overflow water flows through a dechlorination system that measures the overflow and meters a neutralizing chemical to protect aquatic life.

The commissioning process required the integration of all facility components, including scheduling of water flows and Metro Vancouver operations staff to fit around the requirements of an operating water supply system that could not afford any interruptions. It confirmed reliable water supply continuity under multiple simulated failure scenarios.

SOCIAL AND/OR ECONOMIC BENEFITS

The BHT/ERF is expected to generate energy equivalent to powering up to 1,000 homes. Instead, the energy is used to partially offset consumption of one of the large 2,000 HP pumps in Metro Vancouver's Capilano Pump Station.

The energy production of the turbine is metered by BC Hydro and credited against Metro Vancouver's account for the Capilano Pump Station. The expected energy production under forecast water demand is anticipated to reduce Metro Vancouver's total energy consumption by approximately 9,600 MWh/year. The cost savings due to reduced electricity purchases will recover the costs of the energy recovery turbine in less than 10 years, and will continue to reduce operating costs for Metro Vancouver taxpayers into the future.

metrovancouver

PROJECT OWNER

The BHT/ERF reduces Metro Vancouver's operating costs.

CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

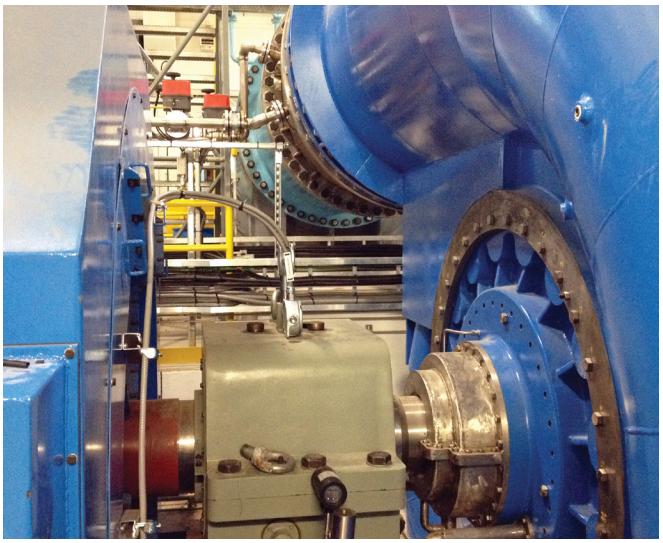
ENVIRONMENTAL BENEFITS

Knight Piésold extensively considered aesthetic impacts of the facility to minimize any footprint and visual disturbance at the nearby Capilano River Regional Park. The facility has an architectural design with a very low surface profile, having a completely underground concrete tank into which the PRVs and turbine discharge. The tank features a unique wrap-around design that kept all machinery and devices out of the tank to facilitate maintenance without dewatering.

Knight Piésold took into account water quality considerations by using special biodegradable hydraulic fluids that comply with drinking water standards and are safe for human consumption for equipment that controls the turbine. This eliminated water contamination risk had the equipment used standard hydroelectric lubricating and hydraulic oils. Similarly, the internal passages of the turbine are lined with an epoxy that meets stringent NFA standards for use in drinking water applications.

CAPILANO RESERVOIR

Aquatic habitat sensitivity in the adjacent Capilano Reservoir was a key consideration.



GENERATOR BEARINGS

Generator bearings used biodegradable hydraulic fluids safe for drinking water.

CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

Knight Piésold looked into aquatic habitat sensitivity in the adjacent Capilano Reservoir. Treated water contains chlorine for drinking water safety that may potentially harm aquatic habitat if the treated water is directly returned to the Capilano Reservoir. Knight Piésold developed and upgraded a dechlorination system that delivers a metered dosage of calcium thiosulphate, an environmentally benign chemical, to neutralize residual chlorine without any inherent side effects.

After continuously monitoring the operation of the dechlorination system during commissioning, the dechlorination system demonstrated to successfully remove all residual chlorine. Neutralized water is returned to the Capilano Reservoir through an emergency overflow channel in the event of a system failure.

DECHLORINATION SYSTEM

The dechlorination system covers overflow conditions in three orders of magnitude and accurately delivers a metered dosage of calcium thiosulphate to neutralize residual chlorine in the water, protecting aquatic habitat in the Capilano Reservoir.

DECHLORINATION CHANNEL

Dechlorination channel, measurement weir, and calcium thiosulphate dosing header.

CAPILANO BREAK HEAD TANK AND ENERGY RECOVERY FACILITY

PROJECT HIGHLIGHTS

MEETING CLIENT'S NEEDS

Knight Piésold acted as the prime design consultant and Owner's Engineer from the project's inception, and recently completed the supply and installation of the energy recovery turbine, upgraded the dechlorination system, and conducted the final commissioning of the complete facility. Knight Piésold used its Integrated Management System, an in-house, web-based project management system, to track engineering budget and schedule.

Metro Vancouver is committed to providing clean, safe drinking water and to ensuring its sustainable use. Having worked closely with Metro Vancouver, Knight Piésold met the April 2015 deadline of delivering water to residents and businesses in the cities. With four separate control systems (one for the turbine, one each for the two PRVs, plus a supervisory PLC), the BHT/ERF has proven during commissioning to seamlessly provide reliable water supply continuity under all anticipated failure modes.

The BHT/ERF also showcases Metro Vancouver's commitment to reduce energy consumption and increase energy recovery from the regional water system. At a total installed electrical generation capacity of 1,687 kW at a design flow rate of 7.5 m^3/s, the BHT/ERF includes one of the largest energy recovery turbines in a municipal treated potable water system in North America. Power is generated at 4.16 kV before being transformed to 13.8 kV and is then fed to partially offset the energy consumption of the large pumps in Metro Vancouver's Capilano Pump Station.

DOCUMENTARY

Metro Vancouver produced a documentary "Sounds from the Break Head Tank" to capture the outstanding acoustics in the underground tank. Eight musicians performed an original score at the tank before it was filled with more than 3 million liters of water for the commissioning of the Seymour-Capilano Twin Tunnels System.